

How do environmental and management factors affect ecosystem services from corn-soybean-based agricultural systems?

Abha Bhattarai^{1,2}, Sami Khanal^{1,2}

INTRODUCTION

Midwest region produces >80% of corn-soybean in US [1] and CO₂ equivalent emissions from agriculture = 29% of total US emissions from agriculture [2]

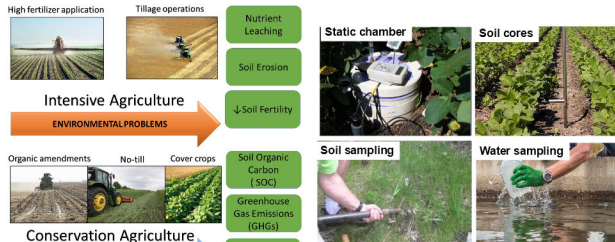


Figure 1. Intensive vs Conservation agriculture

- Conventional field-based data collection approaches to assess the impacts of management and environmental variables are **time and cost prohibitive** to scale-up to a larger landscape (Figure 2)
- Biogeochemical models** such as **DeNitrification DeComposition (DNDC) model** are cost-effective and can simulate ecosystem services well for long periods of time

OBJECTIVES

- To simulate ecosystem services such as GHGs and SOC for agricultural sites
- To assess effect of management practices on the ecosystem services

METHODS

Table 1. Management details of the field under study

Crop	Tillage	Fertilizer	Organic amendments
Corn- Winter	Mixed tillage; chisel plow,	Urea and Ammonium nitrate (UAN) : 62 kg N/ha ($\times 2$) for corn +	Dairy manure at 302 kg N/ha & 82 kg P/ha
Wheat- Alfalfa $\times 3$	disc & harrow, field cultivator	94 kg N/ha for winter wheat	

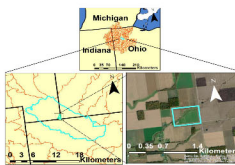


Figure 3. Location of study area within sub-basin of Maumee River Watershed

Observation type and unit	Source	Frequency
Water discharge, mm	Tile drainage outlet monitored using ISCO 4230 Bubbler Flow Meters	Daily
Total nitrate NO ₃ -N, kg N/ha	Tile drainage outlet monitored using ISCO 6712 Portable Sampler	Daily
Crop Yield, tons/acre	Harvested for silage	Annual

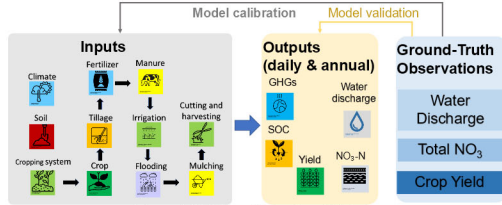


Figure 4. DNDC model Inputs and Outputs

RESULTS

Table 3. Details of simulated scenarios

Scenarios	Tillage	Cover crop	Fertilizer
Baseline (B)	Mixed (disk/chisel +moldboard)	No	UAN
Baseline +No till (B+NT)	No	No	UAN
Baseline +Cover crop (B+CC)	Mixed (disk/chisel +moldboard)	Yes	UAN
Baseline +Cover crop+ No till (B+CC+NT)	No	Yes	UAN
Baseline + Manure (B+M)	Mixed (disk/chisel +moldboard)	No	UAN +Manure
Baseline + Manure +No till (B+M+NT)	No	No	UAN +Manure

Annual and Seasonal Emissions

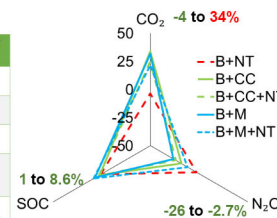


Figure 5. 20-year annual change in GHG emissions and SOC from baseline

- Net **decrease** in N₂O emissions from baseline with alternative scenarios. Greatest reduction with **B+M**
- Net **increase** in SOC from baseline with alternative scenarios. Highest increase with **B+M+NT**

- Net **increase** and **decrease** in CO₂ emissions from baseline. Reduction in emissions with **B+NT** and highest increase in emissions with **B+CC**

- Annual average N₂O emission ranged from **2.3 to 3.2 kg N/ha**
- Peak in corn years due to **N fertilization**

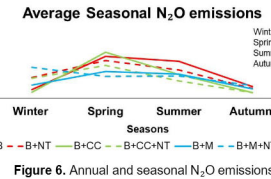
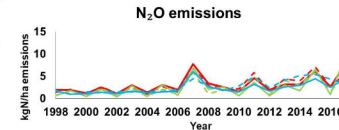


Figure 6. Annual and seasonal N₂O emissions

- 64-70%** of annual N₂O emissions from spring and summer
- Higher** simulated emission compared to field-based measurements is likely due to **high clay content** of soil

CONCLUSIONS

- Using the calibrated and validated DNDC model, the relationships between GHG emissions and management practices in a corn-dominated cropping system were evaluated.
- Using the simulated outputs, following observations were made:
 - N₂O emissions peak in years planted with corn, and after fertilization events
 - CO₂ emissions peak in years planted with corn with tillage
 - SOC sequestration increased by No-till and cover crop practices
 - Ecosystem services vary due to specific soil and weather conditions
 - Trade-off between management practices should be considered

REFERENCES

- Food and Agriculture Organization Statistics Division. (2018). *Crop Production Database*.
- Larsen, J., Damassa, T., & Levinson, R. (2007). Charting the Midwest: an inventory and analysis of greenhouse gas emissions in America's heartland. World Resources Institute.
- Williams, M. R., King, K. W., Ford, W., & Fausey, N. R. (2016). Edge-of-field research to quantify the impacts of agricultural practices on water quality in Ohio. *Journal of Soil and Water Conservation*, 71(1), 9A-12A.

Soil Organic Carbon

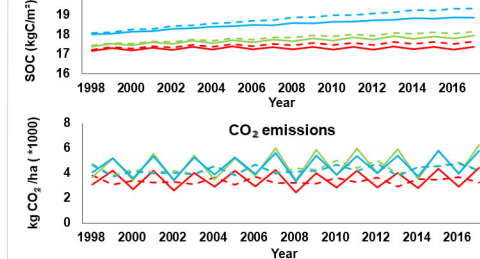


Figure 7. Annual SOC and CO₂ emissions

- Average SOC ranged from **17.3 to 18.8 kgC/m²**, varying from **1-8.6%** from baseline
- Average CO₂ ranged from **3,382 kg C /ha/yr to 4,704 kg C/ha/yr**, varying from **-4 to 34%** from baseline
- Peak in CO₂ emissions for **corn years** when soil was tilled, and in **soybean years** for no-till scenarios due to decomposition of higher residue of corn from previous year
- Cover crops and No-till **increase** CO₂ emissions but also **increase** SOC sequestration

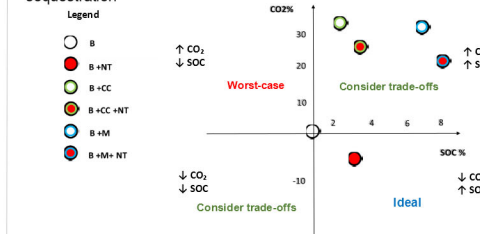


Figure 8. Classifying scenarios according to SOC and CO₂

FUTURE WORK

- Simulate the ecosystem services for unique soil types and under climate change scenarios
- Assess the impact of various management practices on ecosystem services at a larger landscape scale

ACKNOWLEDGEMENTS

- Department of Agriculture NIFA (Award no. 2017-67021-26141 and 2019-67019-29310) and Hatch Project #NC1195.
- Bill Salas from Applied GeoSolutions for providing the DNDC model source code.
- Garrett Steinbeck for help with DNDC model calibration and validation
- Help from Margaret Kalcic, Anna Postel, Haley Stockham, Elizabeth Callow, Asmita Murumkar, and Grey Evenson in preparation of weather and management practice data for model runs
- Help from USDA-ARS Kevin King's group in preparation of ground-truth water quality data for model calibration and simulation.